





PERMA-FIX ENVIRONMENTAL SERVICES

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	DATE: May 2014
APPROVED:	
	
_____ Technical Services Manager	_____ 5/31/14 Date
	
_____ Corporate Certified Health Physicist	_____ 5/31/14 Date

1.0 PURPOSE

This procedure establishes the basis and methodology for the placement and use of air monitoring equipment, as well as the collection, analysis, and documentation of air samples. Radiological air sampling and analysis is performed to monitor concentrations of radionuclides in the air for purposes of tracking internal radiation exposure to occupational radiation workers, determining appropriate respiratory protection devices, establishing radiological posting boundaries, verifying effluent airborne radioactivity concentrations, and providing information on radiological conditions in the work area.

2.0 APPLICABILITY

This procedure applies to all radiological air monitoring activities performed in support of Perma-Fix Environmental Services (PESI) activities.

3.0 REFERENCES

1. Title 17, California Code of Regulations, Division 1, Chapter 5, Subchapter 4 "Standards for Protection Against Radiation."
2. Perma-Fix Environmental Services (PESI), "Radiation Protection Plan (RPP)"
3. Rock, R.L., *Sampling Mine Atmospheres for Potential Alpha Energy Due to the Presence of Radon-220 (Thoron) Daughters*, Informational Report No. 1015, United States Department of the Interior, Mining Enforcement and Safety Administration, 1975.
4. Kusnetz, H.L., Radon Daughters in Mine Atmospheres, A Field Method for Determining Concentrations, Am. Ind. Hyg. Assoc. Quat., Vol. 17, No. 87, 1956.
5. ANSI N13.1, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.
6. Regulatory Guide 8.25, Air Sampling in the Workplace.
7. 29 CFR 1910.1096, United States Occupational Health & Safety, Ionizing Radiation.

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4.0 DEFINITIONS

Airborne Radioactivity: Radioactive material in any chemical or physical form that is dissolved, misted, suspended, or otherwise entrained in air.

Ambient Air: Air in the volume of interest, such as room atmosphere, as distinct from a specific stream or volume of air that may have different properties.

Annual Limit on Intake (ALI): The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man that would result in a committed effective dose equivalent (CEDE) of 5 rems or a committed dose equivalent (CDE) of 50 rems to any organ or tissue.

Breathing Zone (BZ): A uniform description of the volume of air around the worker's upper body and head which may be drawn into the lungs during the course of breathing.

Committed Dose Equivalent (CDE): The dose equivalent to tissues or organs of reference that will be received from an intake of radioactive material by an individual during the 50-year period following the intake.

Committed Effective Dose Equivalent (CEDE): The sum of committed dose equivalents (CDEs) to various tissues in the body, each multiplied by the appropriate weighting factors found in 10 CFR 20.

Derived Air Concentration (DAC): The concentration of a given radioactive nuclide in air which, if breathed by the reference man for a working year of 2000 hours under conditions of light work (1.2 m³ of air per hour), would result in an intake of one (1) ALI.

DAC-hour (DAC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the DAC for each radionuclide) and the time of exposure to that radionuclide in hours. A facility may take 2000 DAC-hr to represent 1 ALI.

Grab Sample: A single sample of ambient air collected over a short time.

Maximum Permissible Concentration (MPC): That concentration of radionuclides in air or water that will result in the Maximum Permissible Body Burden or Organ Burden and result in a whole body or organ receiving the annual dose limit if breathed in by a worker for 2000 hours.

Monitoring: The measurement of radiation levels, airborne radioactivity concentrations, radioactive contamination levels, quantities of radioactive material, or individual doses and the use of the results of these measurements to evaluate radiological hazards or potential and actual doses resulting from exposures to ionizing radiation.

MPC-hour (MPC-hr): The product of the concentration of radioactive material in air (expressed as a fraction or multiple of the MPC for each radionuclide) and the time of exposure to that radionuclide in hours.

Occupational Dose: An individual's ionizing radiation dose (external and internal) received as a result of that individual's work assignment.

Protection Factor: The degree of protection given by a respirator. The protection factor is used to estimate radioactive material concentrations inhaled by the wearer and is expressed as the ratio

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of ambient concentration of airborne radioactive materials to the concentration that can be maintained inside the respirator during use.

Representative: Sampling in such a manner that the sample closely approximates both the amount of activity and the physical and chemical properties of the material (e.g., particle size and solubility in the case of aerosol to which workers are exposed). Air sampling performed within the Breathing Zone (BZ) is considered representative of the airborne radioactive material concentration inhaled by the worker.

Restricted Area: An area to which access is limited to protect individuals against undue risks from exposure to radiation, radioactive materials, and chemical contaminants. All posted radiological or chemical areas are Restricted Areas.

5.0 RESPONSIBILITIES

5.1 Radiation Safety Officer (RSO)

- Manages the implementation of this procedure.
- Ensures technicians performing activities under this procedure are competent and have sufficient experience to perform assigned tasks.

5.2 Radiation Protection Technician (RPT)

- Initiates, collects, submits, counts, and documents air samples according to the requirements of this procedure, and the SSHP.
- Ensures he / she has sufficient experience and / or knowledge to perform assigned duties under this procedure.

6.0 PRECAUTIONS AND LIMITATIONS

- Running air samplers for extended periods may cause excessive dust loading of the filter media. The frequency of filter change-out should be increased if excessive dust loading is observed.
- Air samplers shall not be used in combustible / explosive atmospheres.
- Air sampling and sample counting equipment shall not be operated beyond their respective calibration periods.
- Air samples shall be taken in such a manner as to not contaminate the filter with materials that were not airborne during the sample interval or by re-suspension of loose contamination from surfaces near the sampling head.
- Sampler exhaust may cause the re-suspension of loose surface contamination if the sampler is positioned improperly.
- Consider higher volume air samplers when covering short duration tasks.
- The decision to provide individual monitoring devices to workers is influenced by the expected levels of intake, likely variations in dose among workers, and the complexity of measurement and interpretation of results.

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7.0 ACTION STEPS

7.1 Air Monitoring Methods

1. Utilize the following monitoring methods to implement the radiological air monitoring program:
 - General Area (GA) Air Monitoring
 - Breathing Zone (BZ) Air Monitoring
 - Passive Radon Monitoring
 - Particulate Radon Grab Samples
 - Perimeter Monitoring, frequently referred to as Air Environmental (AE)
2. Air sampling equipment should be placed so as to:
 - Not directly contact a contaminated (transferable) surface.
 - Minimize interference with the performance of work.
 - Be easily accessible for changing filters and servicing.
 - Be downstream of potential release points.
 - Minimize the influence of supply airflow.
3. An airflow study of any indoor area to be monitored should be performed prior to placement of the sampler (other than BZ samplers). Additional studies should be performed after changes in the work area setup, ventilation systems, or seasons, if seasonal changes may affect airflow patterns.
4. Perform BZ air sampling in occupied areas where, under typical conditions, a worker is likely to be exposed to an air concentration of 10 % or more of the DAC.

7.2 General Area (GA) Air Sampling

1. GA samples are typically taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. GA sampling shall be performed with instrumentation operating at volumes capable of meeting the Minimum Detectable Concentration (MDC) values established in the Technical Basis Document for Dosimetry and Air Sampling.
3. GA samples should be collected:
 - During work activities as a supplement to Breathing Zone (BZ) sampling as deemed appropriate.
 - At site boundaries to confirm effluent air discharge concentrations. These are the Air Environmental (AE) type samples.
 - At discharge points to determine the worst case airborne radiological conditions.
4. Document airflow studies, if performed in the appropriate project logbook or as directed by the RSO.

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5. Select a calibrated low / high volume sampler with the appropriate glass fiber air filter and place the sample head into position. The fuzzy side of the filter should face outwards.
6. Turn the sampler ON. At a minimum, document the following information on the air filter envelope or log sheet:
 - Sampling station identifier (as determined by the RSO)
 - Sampler model
 - Serial number
 - Date / time on
 - Flow rate
 - On by (individual starting sampler)
7. When air monitoring is complete, observe the sampler flow rate and turn the sampler off. At a minimum, document the following information on the air filter envelope or logsheet:
 - Date / time off
 - Flow rate
 - Off by (individual terminating sample)
8. Remove and / or replace the sample head and filter using caution to prevent cross-contamination.
9. Store the filter in a protective container to minimize the loss of collected material.
10. Submit sample to counting lab for analysis.

7.3 Breathing Zone (BZ)

1. Specific instructions on the use and calibration of Lapel Samplers are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Collect BZ samples during entries into posted airborne radioactivity areas and during activities which have a reasonable potential of producing airborne radioactivity (e.g., excavating contaminated soils, surface destructive activities on surfaces with fixed contamination) as determined by the RSO.
3. Position the sampler on the individual representative of the worst-case exposure for the group if a single lapel sampler is used for multiple members of a work group. Base this selection on operating experience and consultation with the RSO. A single lapel sampler should be used for a group of no more than four workers spending greater than one hour in the work area under the same RWP.
4. Ensure the sample head is positioned as close to the breathing zone as practical without interfering with the work or the worker.
5. Operate lapel samplers according to the appropriate instrument use procedure. At a minimum, document the following information on the air filter envelope or log sheet:
 - Wearer's name(s)
 - Applicable Hazardous Work Permit (HWP) number

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- Sampler model / serial numbers
 - Date / time On
 - Flow rate (sampler must be running)
 - On by (individual starting sampler)
6. Upon exit from the work area, note the flow rate, turn the sampler OFF and detach from the worker / object. Note that sampling may be suspended / restarted during the workday to facilitate break periods. Accurate volume tracking is crucial during these periods of non-operation.
 7. Perform necessary post-operation sampler checks according to the specific instrument use procedure.
 8. Carefully, remove the air filter from the sample head and place in air filter envelope. Complete the pre-printed air filter envelope or sample log sheet:
 - Date / time off
 - Flow rate
 - Off by (individual stopping sampler)
 9. Submit sample to Counting Room for analysis.

7.4 Radon and Thoron Progeny

1. High volume or low volume grab samplers such as HV-1, LV-1, or RAS-1 (typically in the 35-75 lpm range) should be used for collecting radon and thoron samples.
2. Radon and thoron samples should be collected:
 - During work activities as deemed appropriate by the RSO or designee.
 - At restricted area boundaries as deemed appropriate by the RSO or designee.
 - Each frequently occupied work location should have its own samplers.
 - Airflow patterns should be considered in placing samplers so that the sampler is likely to be in the airflow downstream of the source.
 - A simultaneous background sample shall be taken upwind of all activities when radon and thoron sampling is performed. This sample is critically important.
 - When collecting a radon and thoron breathing zone sample, the sampler should be located in the breathing zone for the worker. Preferably it should be held immediately downwind of the worker and moved around with the worker.
3. Select a calibrated high volume sampler with a 47 mm filter and place the sample head into position. The preferred filter is a membrane filter such as the F&J Specialty Products, Inc. model number A020A047A or equivalent. Alternatively, a glass fiber filter such as the F&J Specialty Products, Inc. model number AE-47 or equivalent can be used

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4. Turn the sampler ON and complete the required information on the air filter envelope to include:
 - RWP number, if appropriate
 - Sampler model and serial number
 - On date, time, and flow rate
 - On by (site worker initials)
 - Sample location
5. Collect a sample for exactly 5 minutes, with no more than a 5-second uncertainty. Exercise caution when handling sample head so as not to cross-contaminate the air filter.
6. Remove air filter from sample head and place in air filter envelope. Complete the required information on the air filter envelope including:
 - Off date, time, and flow rate
 - Site worker stopping the sampler
7. Submit the sample to the counting room within 30 minutes after collection. Samples must be counted between 40 and 90 minutes, or they will be void.
8. Analyze the sample in accordance with Sections 8.1 or 8.2, whichever is appropriate.
9. Alternate industry-accepted methods for Radon-Thoron monitoring may be used at the discretion of the RSO with concurrence from the Project Certified Health Physicist.

7.5 Perimeter Environmental Air (AE) Sampling

1. Perimeter samples are taken with low volume samplers such as LV-1 or equivalent. Specific instructions on the use and calibration of the LV-1 sampler are detailed in RP-110 *Operation of Low Volume Air Samplers*.
2. Perimeter samples are collected to verify compliance with off-site release criteria.
3. Samples are collected at locations designated by the RSO. The air sampling locations should be established at the most likely downwind perimeter boundary, as determined by evaluation of local meteorological data, and / or the nearest perimeter boundary from active work areas.
4. Perimeter samplers should be operated 24 hours a day 7 days a week if possible.
5. Filters from continuously operating perimeter air samplers are normally changed out weekly. Filter change-out of perimeter air samplers will be performed at a frequency long enough to ensure acceptable counting statistics and short enough to maintain consistent sampler flow rates.
6. Perimeter sampler operation shall be verified on a daily basis around locations when airborne generating activities are in progress. This requirement may be relaxed by the RSO for samplers with data logging capability.

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7. Document daily verification (i.e., flow rate) and notify the RSO of any discrepancies. Replace filter and investigate pump operation if daily flow rates vary by greater than 20%.
8. Any sampler that is out of service due to malfunction for more than 1 hour and any invalid samples should be brought to the attention of the RSO.
9. Samples are to be collected in accordance with Section 7.2, Steps 5-10.

7.6 Passive Radon Monitoring

1. Passive radon monitoring methods include the use of either alpha track-etch detectors or electrets.
2. Detectors should be placed for a length of time, so that the minimum detectable concentration is 0.1 pCi/l or less, following manufacturer guidelines. The length of placement is generally 1 month or greater. Locations selected should be representative of the breathing zone, when practical. A simultaneous background sample should always be taken at a location unaffected by site activities. This sample is critically important.
3. Open the bag containing the detector and place the detector in a protective container to allow for air circulation. Follow manufacturer guidelines to activate the detector, as necessary.
4. Record in the logbook:
 - Sample location
 - Date and time of placement
 - Serial number of the detector
 - Initials of the worker placing the detectors
5. Ship the detector to the manufacturers processing center to read the results.

8.0 ANALYSIS OF AIR SAMPLES

General Area (GA), Breathing Zone (BZ), and Perimeter Air (PA) samples should be submitted to a counting room or off-site laboratory for gross alpha/beta analysis. Samples may be sent to an outside laboratory for isotopic analysis as necessary per the RSO.

8.1 Analysis for Radon and Thoron Progeny from a 5 -Minute Low Volume Grab Sample

- 8.1.1 Count the sample twice for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The first count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of sample collection. The second count should start at least 5 hours after the end of the count, but not greater than 17 hours after the end of the first count. Count the sample for 5 minutes each time.

NOTE: It is not recommended that a gas flow proportional counter be used for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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- 8.1.2 Calculate the thoron progeny (TDC) in working levels from the delayed (second) count as follows:

$$TDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Th}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Th} = Working level factor from Graph 1 (Attachment 1).

- 8.1.3 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{\left(\frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF} - TDC \times 16.5 \right)}{F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

TDC = Thoron Progeny determined from second count.

8.2 Alternate Method for the Analysis of Radon Progeny from a 5-Minute Low Volume Grab Sample

This section only applies to the determination of radon and not the determination of thoron.

- 8.2.1 Count the sample once for alpha activity using a Ludlum 2929, Ludlum 2000, or Equivalent. The count should start at least 40 minutes after the end of the sample, but not greater than 90 minutes at the end of the count. Count the sample for 5 minutes.

NOTE: It is not recommended to use a gas flow proportional counter for this analysis as there is a reasonably high probability of contaminating the instrument with radon and / or thoron progeny.

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- 8.2.2 Calculate the radon progeny (RDC) in working levels from the first count as follows:

$$RDC = \frac{cpm_{net}}{E \cdot V \cdot CE \cdot SAF \cdot F_{Rn}}$$

where,

cpm_{net} = (gross counts/count time) - background cpm of counting instrument

V = Volume of air in liters

E = efficiency of counting instrument

CE = Filter collection efficiency (normally 0.998)

SAF = Self absorption factor (normally 0.7 for glass fiber filters and 1.0 for membrane filters)

F_{Rn} = Radon working level factor from Graph 2 (Attachment 2).

9.0 REPORTS

Maintain air monitoring instrument data, sampling data, and analysis results as a quality record.

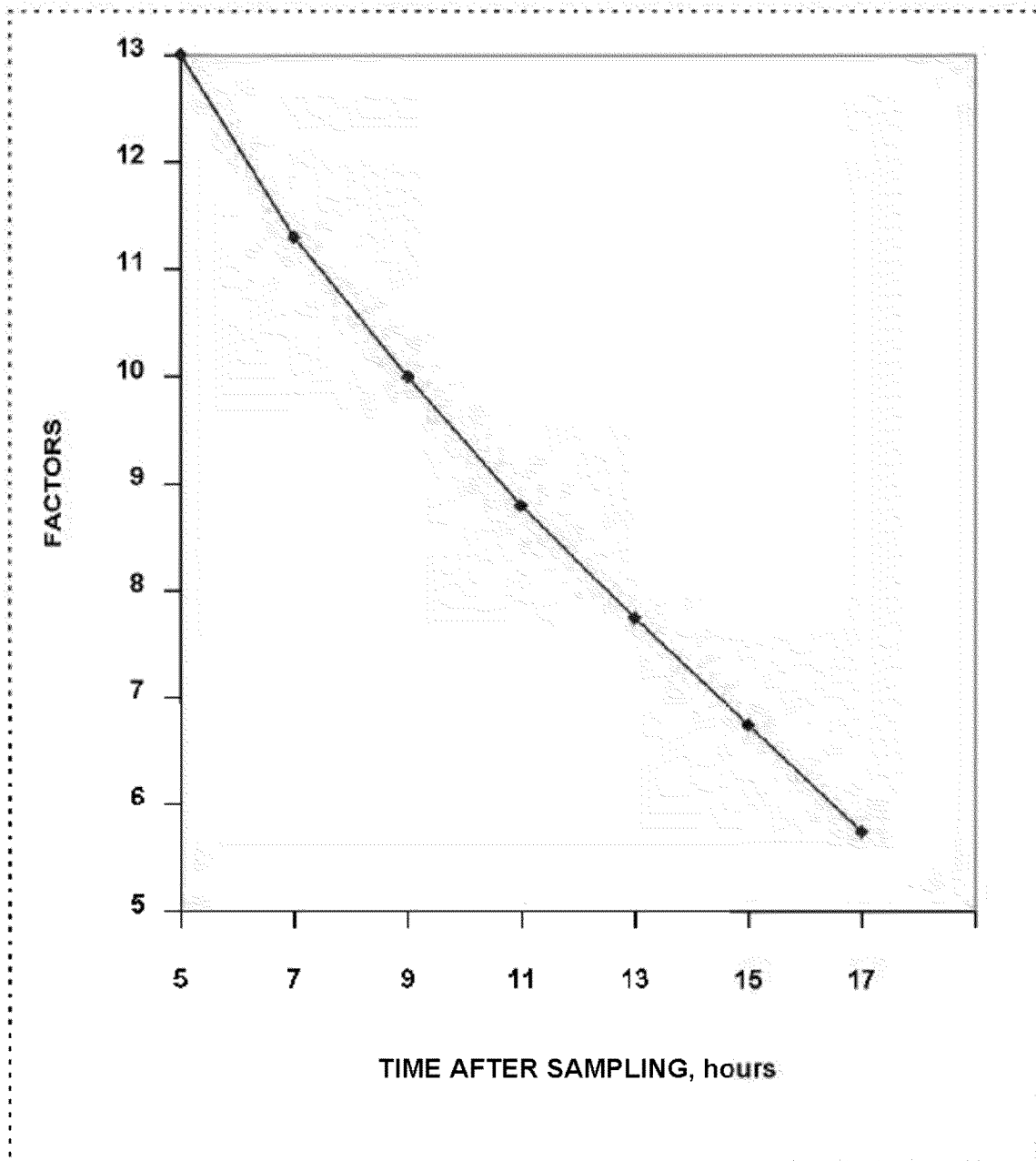
10.0 ATTACHMENTS

Attachment 1 Graph 1, Thoron Working Level Factors

Attachment 2 Graph 2, Radon Working Level Factors

ATTACHMENT 1

GRAPH 1, THORON WORKING LEVEL FACTORS



Time factors versus time after sampling for thoron daughter samples.

TITLE:

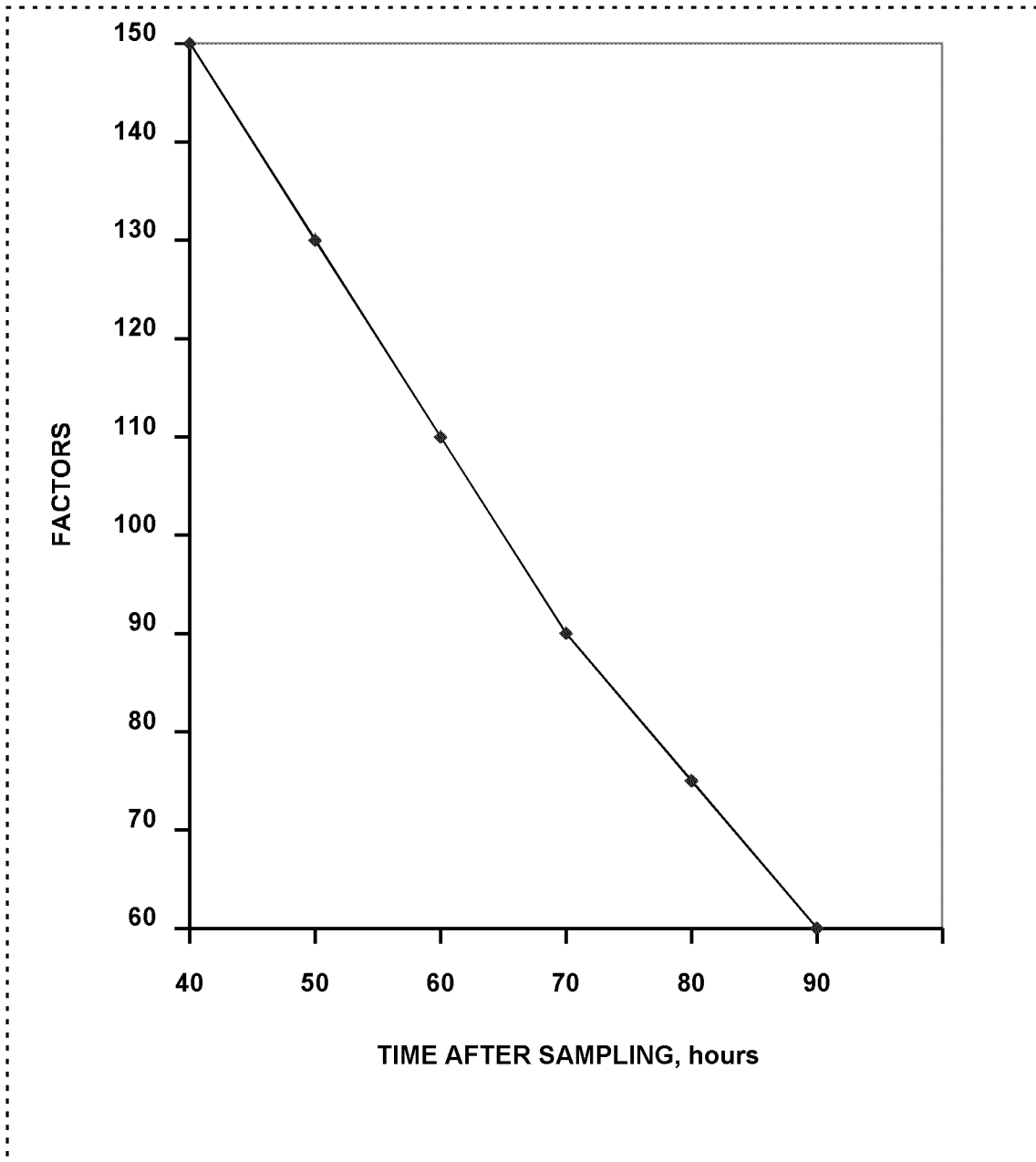
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ATTACHMENT 2

GRAPH 2, RADON WORKING LEVEL FACTORS



Time factors versus time after sampling for radon daughter samples.